(54) [Title of the Invention]   IMAGE-BLUR-CORRECTABLE CAMERA

(57) [Abstract]

[Object]   To achieve a satisfactory imaging performance of an image taking optical system including image blur correcting means even during driving of the image blur correcting means.

[Construction]   There are provided image blur correcting means 1 and 2 which correct an image blur in response to output of means 3 which detects the amount of blur, and aperture control means 10 which controls aperture operation of a taking lens system 6.  Aperture limiting means 1 which avoids an open aperture during operation of the image blur correcting means by limiting the aperture controlling range of the taking lens system by the aperture control means is provided.  The limiting range of the aperture control means is made limitable in response to the condition of the taking

lens system, output of the image blur detecting means, the operating range of the image blur correcting means and the like. The aperture limiting means is made inoperable in the non-operating state of the image blur correcting means.

[Claims]

[Claim 1]   An image-blur-correctable camera comprising:

image blur detecting means which detects an amount of image blur;

image blur correcting means which corrects an image blur in response to output of said image blur detecting means;

aperture control means which controls aperture operation of A taking lens system; and

aperture limiting means which limits the aperture controlling range of the taking lens system by said aperture control means during operation of said image blur correcting means.

[Claim 2]   An image-blur-correctable camera according to claim 1, wherein:

said aperture limiting means limits the control range of the aperture control means so that the aperture of the taking lend system does not become open.

[Claim 3]   An image-blue-correctable camera according to claim 1, wherein:

said aperture limiting means limits the control range of the aperture control means in response to the condition of the taking lens system.

[Claim 4]   An image-blur-correctable camera according to claim 1, wherein:

said aperture limiting means limits the control range of the aperture control means in response to output of the image blur detecting means.

[Claim 5]   An image-blur-correctable camera according to claim 1, wherein:

said aperture limiting means limits the control range of the aperture control means in response to the operating range of the image blur correcting means.

[Claim 6]   An image-blur-correctable camera according to claim 1, wherein:

the aperture limiting means is made inoperable in the non-operating state of the image blur correcting means.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]   The present invention relates to an image-blur-correctable camera capable of preventing an image blur caused by hand vibration or the like.   More particularly, the invention relates to an image-blur-correctable camera of which the exposure control operation during image taking is improved.

[0002]

[Description of the Related Art]   In recent cameras, introduction of electronic technology is remarkable for various parts including the automatic exposure (AE) mechanism and the auto-focus (AF) mechanism, and are highly

automated.  A program automatic exposure mechanism, for
example, automatically selects a required aperture and a
shutter speed in response to the brightness on the object
side, the film sensitivity used, and the condition of use of
electronic flash to control exposure of the camera.

[0003]  One of the problems involved in trials for
automation in cameras of this type is the solution to
picture blur caused by hand shaking resulting from hand-hold
imaging.  More specifically, to prevent image blur caused by
camera shaking, or particularly, by camera inclination, in a
camera of this type, there are proposed various image blur
correcting apparatus based on steps of detecting shaking or
vibration of the camera by means of an angular speed sensor
or the like, and shift-driving the taking lens system
serving as a main optical system or the optical system
forming a part of this taking lens system in response to the
result of this detection, thereby achieving an image blur
correcting apparatus having a configuration permitting
correction of an image blur.

[0004]  In a camera having such an image blur correcting
apparatus, an image blur is eliminated by movably
controlling the taking lens system or a part thereof as an
image blur correcting optical system, thus making it
possible to take pictures under a condition free from image
blur even with an exposure at a shutter speed lower than an

ordinary pickup.

[0005]   Among cameras capable of accomplishing such an image blur correction, there is known a case disclosed, for example, in Japanese Unexamined Patent Application Publication No. 3-150540 presenting an exposure control operation.   In a camera performing program automatic exposure, even when an image blur correcting apparatus is installed so as to achieve a construction permitting image blur correction, performance of exposure control operation with the conventional program exposure prevents the image blur correcting apparatus from fully displaying its function upon taking in a natural light or upon taking under electronic flash.   The disclosed conventional technology is for solving such an inconvenience.

[0006]   That is, in a conventional camera capable of correcting an image blur, means for determining whether the image blur correcting apparatus is operating or not is provided.   When it is determined that image blur correction is being carried out, the program diagram combining the lens aperture value and the shutter speed during taking is shifted so as to select a program diagram on the lower shutter speed side as compared with that of ordinary taking without image blur correction.

[0007]

[Problems to be Solved by the Invention]   As image blur

correcting apparatuses used in image-blur-correctable cameras as described above, the one based on a method of preventing an image blur by shifting a part of the taking lens system as an image blur correcting lens system and the like have conventionally been known in general.

[0008]  However, in these conventional types, an optical design problem lies in that, when using a clear lens having a small f-number, designing becomes more difficult according as it is tried to maintain a better imaging performance brought about by luminous fluxes passing through the lens periphery.

[0009]  Another image blur correcting apparatus different from the above-cited one, using a variable apex prism has conventionally been known as well.  In this case also, the color aberration of luminous fluxes passing through the prism periphery is a problem in keeping an imaging performance.

[0010]  Another inconvenience in the conventional cases described above is that, when the object side has a low brightness, the lens aperture eventually becomes open, thus making it impossible to solve design problems of the taking optical system.  There is therefore a demand for working out some solutions to sweep away such a problem.

[0011]  The present invention was developed in view of these circumstances and has an object to provide an image-blur-

correctable camera which gets rid of the conventional
problems occurring when using an image blur correcting
apparatus and thus can maintain always a satisfactory image
quality even during operation of the image blur correcting
apparatus.

[0012]

[Means for Solving the Problems]   To comply with this demand,
the image-blur-correctable camera of the present invention
comprises image blur detecting means; image blur correcting
means which corrects an image blur in response to output of
the image blur detecting means; aperture control means which
controls aperture operation of the taking lens system; and
aperture means which limits the aperture controlling range
of the taking lens system by the aperture control means
during operation of the image blur correcting means; thereby
enabling to limit the aperture of the taking lens system to
become an open aperture.

[0013]   The image-blur-correctable camera of the present
invention has a configuration in which the aperture
controlling means controls the aperture of the taking lens
system so as to prevent operation of the taking lens system
from becoming open, or so that the control range of the
aperture controlling means is limited in response to the
condition of the taking lens system, output of the image
blur detecting means, the operating range of the image blur

correcting means or the like, or so as to prevent operation

thereof during non-operation of the image blur correcting

means.

[0014]

[Operation]  According to the present invention, the

controlling range of the aperture control means is limited

by the aperture limiting means so that the aperture of the

taking lens system does not become open even when the object

side has a low brightness during operation of the image blur

correcting means, thus permitting maintenance of

satisfactory imaging performance and taking image quality of

the taking lens system.

[0015]

[Embodiments]  Fig. 1 illustrates an embodiment of the

image-blur-correctable camera of the present invention.  In

Fig. 1, reference numeral 1 represents a CPU unit which

performs correcting driving control of the image blur

correcting optical system by using various values of

detecting unit output.  The CPU unit 1 has an ROM unit or a

RAM unit for storing numerical values necessary for

arithmetic operation.

[0016]  Reference numeral 2 represents a correcting driving

unit which is driving-controlled by output signals from the

CPU unit 1 and shift-drives an image blur correcting lens

group 6d forming an image blur correcting optical system

(forming a part of the taking lens system 6 described later).

The blur correcting driving unit 2 has a monitor unit which

detects the amount of shift of the image blur correcting

optical system and sends a monitor signal to the above-

mentioned CPU unit 1.

[0017]   Reference numeral 3 represents a blur detecting unit

which is fixed to an enclosure 5 of the camera apparatus,

detects an angular speed of a rotation blur of the camera

apparatus, and outputs the signal thereof to the CPU unit 1.

A publicly known vibrating gyro angular speed meter may be

used as an angular speed detecting element in this blur

detecting unit 3.   The blur detecting unit 3 is not of

course limited to this.

[0018]   Reference numeral 4 represents a focal position

detecting unit which detects the position of a focus

adjusting optical system in the taking lens system 6

described later.   This focal position detecting unit 4

serves as an encoder which reads out a rotating position of

a focus cam ring 7 described later, and can detect a driving

status of the taking lend system 6 (described later).

[0019]   Reference numeral 5 represents an enclosure forming

the camera apparatus composed of a camera body a lens tube.

Fig. 1 schematically shows only an exterior view thereof.

[0020]   Reference numeral 6 represents a taking lend system,

of which the detailed lens system shape and the like are

omitted here in Fig. 1. For example, it is recommendable to use a case of a zoom lens disclosed in the USP 4,978,205 specification of the present applicant. It is not of course limited to such a lens system type, but any other type zoom lens may be used, or a monofocus lens may be used. In this embodiment, the taking lens system 6 has a diameter of F2.8.

[0021] Various parts of the taking lens system 6 will now be described. Reference numeral 6a represents a first lens group (composed of convex lenses). The first lens group 6a is back-and-forth movable relative to the enclosure 5 in the optical axis direction, and performs focal adjustment. First adjustment is carried out through rotation of the focus cam ring 7.

[0022] Reference numeral 6b represents a second lens group (composed of concave lenses). The second lens group 6b back-and-forth movable relative to the enclosure 5 in the optical axis direction, and performs zoom adjustment through combination with a third lens group 6c described below. Reference numeral 6c represents a third lens group (composed of convex lenses). The third lens group 6c is back-and-forth movable relative to the enclosure 5 in the optical axis direction in response to the displacement of the second lens group 6b.

[0023] Reference numeral 6d represents a fourth lens group (composed of convex lenses). The fourth lens group 6d is

movable (shiftable) in a direction perpendicular to the optical axis and performs image blur correction.  The fourth lens group 6d is not movable in the axial direction relative to the enclosure 5.

[0024]   Reference numeral 7 represents a focus cam ring.  A cam groove is provided on a part thereof.  Rotating operation of this focus cam ring 7 causes a movement of the first lens group 6a of the taking lens system 6 in the optical axis direction to permit focus adjustment.

[0025]   Reference numeral 8 represents a zoom cam ring which has two cam grooves for causing movement of the second lens group 6b and the third lens group 6c of the taking lens system 6 in the optical axis direction.  Rotating operation of this zoom cam ring 8 makes it possible to accomplish zoom adjustment.

[0026]   Reference numeral 9 represents a zoom position detecting unit which detects the position of displacement of the zoom adjusting optical system comprising the second and third lens groups 6b and 6c of the above-mentioned taking lens system 6.  It serves as an encoder which reads out the rotating position of the zoom cam ring 8.  This zoom position detecting unit 9 is as well connected to the above-mentioned CPU unit 1 to perform signal communication.

[0027]   Reference numeral 10 represents an aperture driving unit which controls aperture operation and amount of

aperture during image taking by means of signals from the CPU unit 1.

[0028] Reference numeral 11 represents a taking film, and 12, a film sensitivity setting unit. The film sensitivity setting unit 12 automatically reads out the sensitivity of a taking film 11 from a DX code of a film cartridge not shown and signal-communicates it to the CPU unit 1. A manual sensitivity setting member not shown is connected to the film sensitivity setting unit 12, and when a film sensitivity is set by the operation of this manual sensitivity setting member, the setting of this manual sensitivity setting member is given a priority.

[0029] Reference numeral 13 represents a shutter unit which adjusts the exposure time to the taking film 11, and adjusts the exposure time by use of a signal from the above-mentioned CPU unit 1. Reference numeral 14 represents a release switch, and has a semi-pressing operating switch which starts power source operation of the camera and a full-pressing operating switch which starts an exposing operation.

[0030] Reference numeral 15 represents an image blur correction operating switch. This is a switch which selects whether or not the blur correcting driving unit 2 is to be operated for image blur correction during image taking. The operation is switched over to "correction ON" state with the

switch closed, and to "correction OFF" state with the switch open.

[0031] Reference numeral 16 represents a display unit provided outside the camera body of the enclosure 5, which displays image taking information including various setting circumstances of the camera, the shutter speed upon taking, the aperture value and the like, which are used for notifying the cameraman of the information. The details of display are controlled by signals from the above-mentioned CPU unit 1.

[0032] Reference numeral 17 represents a photometer unit which detects brightness of an object to be taken, and outputs the brightness information to the CPU unit 1.

[0033] Reference numeral 18 represents an exposure setting unit which causes the camera operator to set an exposure control mode of the camera, and outputs a setting signal to the CPU unit 1. For example, it sets a mode such as a program AE mode, a shutter preferential AE mode, an aperture preferential AE mode, or a manual mode, and sends a shutter speed set value in the shutter preferential AE mode, or a signal regarding an aperture set value in the aperture preferential AE mode to the CPU unit 1.

[0034] Fig. 2 is a block diagram illustrating the mechanical configuration of the image-blur-correctable camera shown in Fig. 1 above. In Fig. 2, the blur

correcting driving unit 2, the blur detecting unit 3, the
focal position detecting unit 4, the zoom position detecting
unit 9, the aperture driving unit 10, the film sensitivity
setting unit 12, and shutter unit 13, the release switch 14,
the image blur correcting operation switch 15, the display
unit 16, the photometer unit 17 and the exposure setting
unit 18 are connected respectively to the CPU unit 1 to
conduct signal communication.

[0035]   Fig. 3 illustrates the operating sequence in setting
exposure and in exposing operation in the image-blur-
correctable camera of the present invention shown in Fig. 1.
Operations in the following description are those processed
in the CPU unit 1 unless otherwise defined.

[0036]   With the semi-pressing operating switch ON of the
release switch 14, the process is started with step 1
(hereinafter simply referred to as "S").   In S2, a film
sensitivity value (Sv-value in APEX operation) signal is
entered from the film sensitivity setting unit 12.   In S3,
an object brightness value (Bv-value) signal is entered from
the photometer unit 17.

[0037]   Then, in the next S4, an exposure value (Ev-value)
which determines a combination of the above-mentioned
shutter speed value (Tv-value) and aperture value (Av-value)
is calculated.   This Ev-value is determined from $Ev = Sv + Bv$.

[0038] Then, in S5, it is determined whether or not the state of the image blur correcting operation switch 15 is "correction ON" state. When this switch 15 is closed and the state "correction ON" is set, the process advances to the next S6. If the switch 15 is open, and the state "correction OFF" is set, S6 is skipped, and the process goes to S7.

[0039] In the above-mentioned S6, an Av limit value which limits the operating range of the aperture driving unit 10 is set so as to prevent the aperture value of the taking lens system 6 from becoming open during image taking. As this Av limit value, a value stored in the ROM unit of the CPU unit 1 in advance is used. In this embodiment, a value F3.2 (the open f-number of the taking lens system 6 of F2.8 + 1/3 aperture reduced) is assumed to be set as an Av limit value necessary for maintaining a satisfactory depicture performance of the taking lens system 6 within the operable range of the image blur correction driving unit 2.

[0040] In S7, a shutter speed value (Tv-value) and an aperture value (Av-value) to be executed upon taking are fixed on the basis of the Ev-value calculated in S4 above. The condition for combining the Tv-value and the Av-value is to satisfy the above-mentioned formula $Ev = Tv + Av$. Provided however that, upon passing through S6, the process is subject to limitation by an Av-value set in S6, or a Tv-

value of Av-value set by the exposure setting unit 18. In this case, the highest priority is given to the Av limit value set in S6 above. The fixing operation performed in S7 will be described later with concrete examples.

[0041] Then in the next S8, the shutter speed value (Tv-value) and the aperture value (Av-value) fixed in S7 above are displayed on the above-mentioned display unit 16. It is needless to mention that, since the Tv-value and the Av-value resulting from APEX operation are difficult to understand as they are as a conventional display of shutter speed and aperture, information after conversion into values such as "1/250 sec" or "F5.6" as before may be displayed. As described later in Fig. 4, information other than the above such as an exposure error value may be additionally displayed.

[0042] Then, in S9, it is detected whether or not the full pressing operating switch of the release switch 14 is in state ON. If it is not ON, the process goes back to S2 described above since image taking is not as yet conducted. If the state is ON, the process advances to the next S10 to start the taking operation.

[0043] In S10, the exposure operation for image taking is performed. More specifically, though a detailed description is omitted, operation of the blur correction driving unit 2 and operation of the aperture driving unit 10 are

sequentially started (any of these operations may be the first, or they may be simultaneously started), and then, the shutter unit 13 is operated to give a proper amount of exposure to the taking film 11. After the completion of operation of the shutter unit 13, operation of the blur correction driving unit 2 and the aperture driving unit 10 is finished, to return to a prescribed initial state. These are main operations of exposure performed in this S10.

[0044] After the completion of this S10, the process goes to S11, and thus the routine of a series of operations in the exposure setting and exposure operation with the camera of the present invention are completed.

[0045] As is clear from the above description, in this image-blur-correctable camera, when the image blur correction operating switch 15 is in the state "correction ON", the aperture value of the taking lens system 6 during image taking is automatically limited. If the switch 15 is set in the state "correction OFF", on the other hand, the limitation on the aperture value of the taking lens system during image taking is automatically cancelled.

[0046] Fig. 4 is a flowchart for illustrating details of the fixing processing step of the shutter speed value (Tv-value) and the aperture value (Av-value) conducted in S7 shown in Fig. 3 described above.

[0047] First, in S701, it is determined whether or not the

exposure mode is the program AE mode from a signal from the exposure setting unit 18. If it is the program AE mode, the process advances to S704. If not, it goes to S702.

[0048] In S702, it is determined from a signal from the exposure setting unit 18 whether the mode is the shutter preferential AE mode or not. If the shutter preferential mode, the process advances to S705 and subsequent steps. If not, it goes to S703.

[0049] In S703, it is determined from a signal from the exposure setting unit 18 whether or not the mode is the aperture preferential AE mode. If the aperture preferential AE mode, the process goes to S707 and subsequent steps. If not, it advances to S709 and subsequent steps since the setting is the manual mode.

[0050] In S704 in the case where the mode is determined to be the program AE mode in S701 above, a Tv-value and an Av-value under a prescribed program are set, and upon passing through S6 as shown in Fig. 3, the Tv-value and the Av-value are fixed on the basis of the Av limit value set in S6. When an Av limiting value is set in this case, the Av limit value has a higher priority than the prescribed value. After the end of this S704, the process advances to S8 shown in Fig. 3.

[0051] In 705 in the case where the shutter preferential mode is determined in S702 above, a shutter speed set value

is entered in accordance with a signal from the exposure

setting unit 18. Then, in S706, the Tv-value and the Av-

value are fixed on the basis of this shutter speed set value,

and the Av limit value set in S6 upon passing through S6 in

Fig. 3. At this point in time, if an Av limit value is et,

the Av limit value has a higher priority than the shutter

speed set value, depending upon the condition. After the

end of S706, the process advances to S8 in Fig. 3.

[0052] On the other hand, in S707 in the case where the

mode is determined to be the aperture preferential AE mode,

an aperture set value is entered as derived from a signal

from the exposure setting unit 18. Then, the Tv-value and

the Av-value are fixed on the basis of the Av limit value

set in S6 upon passing through S6 in Fig. 3. If an Av limit

value is set, an Av limit value has a higher priority than

the aperture set value, depending upon the condition. After

the completion of this S708, the process advances to S8 in

Fig. 3.

[0053] Finally in S709 in the case where the mode is

determined to be the manual mode in S703 described above, a

shutter speed set value is entered in accordance with a

signal from the exposure setting unit 18. Furthermore, an

aperture set value is entered in S710.

[0054] Then, in S711, the Tv-value and the Av-value are

fixed on the basis of the shutter speed set value, the

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aperture set value, and the Av limit value set in S6 upon passing through S6 in Fig. 3. In this case, not in the AE mode, it is not necessary to satisfy Ev = Tv + Av. However, when an Av limit value is set, the Av limit value has a higher priority than the aperture set value.

[0055] Then, the difference between the Ev-value based on the combination of the Tv-value and the Av-value fixed in S712 (this is assumed to be $Ev\alpha$) and the Ev value calculated in s s4 IN Fig. 3 (assumed to be $Ev\beta$) (the difference being $Ev\delta = Ev\beta - Ev\alpha$) is calculated. In this formula, $Ev\delta$ is an exposure error, being an under-exposure when the sign is minus, and an over-exposure when the sign is positive. If the mode is the manual mode, a display regarding $Ev\delta$ should be made also in S8 shown in Fig. 3. After the end of S712, the process advances to S8.

[0056] Steps from S701 to S712 described above are details of the steps for fixing the shutter speed value (Tv-value) and the aperture value (Av-value) indicated as S7 in Fig. 3 described above.

[0057] Figs. 5 and 6 illustrate the result of fixing of the shutter speed value and the aperture value carried out in S7 in Fig. 3 as described above (details are illustrated in Fig. 4).

[0058] Fig. 5 illustrates the case described in S704 in Fig. 4 where the exposure control mode of the camera by the

exposure setting unit 18 in the program AE mode.

[0059]  More particularly, the program AE diagram in a case where the blur correction driving unit 2 is not activated upon image taking is hereinafter referred to as "P".  When the exposure value (Ev-value) is larger than 9, this diagram "P" is a typical example of the so-called 1:1 program AE diagram in which, for each change in the object brightness of two stages toward a higher brightness, the shutter speed changes by a stage toward a higher speed, and the aperture changes by a stage toward a smaller aperture.  When the Ev-value is smaller than 9, only the shutter speed changes since an aperture smaller than an open F number 2.8 of the taking lens system cannot be set.  The aperture value at this moment is always F2.8.

[0060]  On the other hand, if the program AE diagram in a case where above-mentioned blur correction driving unit 2 is activated during image taking is expressed as "Pco", the aperture stops changing at a point where a set aperture of F3.2 is reached in the program AE diagram since an Av limit value if F3.2 is set for a case where the correction driving unit 2 is activated during image taking as described in the description in S6 in Fig. 3, and an aperture on the open side is not set over this limit.

[0061]  As described above, the f-number of the maximum diameter of the aperture driving unit 10 varies depending

upon whether the blur correction driving unit 2 is activated
or not.  However, when the f-number of the largest possible
diameter during image taking is changed from F2.8 to F3.2,
the shutter speed for the same object brightness becomes
lower only by 1/3 stage.  The image blur correctable limit
brightness on the lower brightness side does not become
worse so much.

[0062]  On the other hand, luminous fluxes passing through
the taking lens system 6 can be cut by about 10% on the
periphery in the radial direction as a result of a change in
the aperture diameter.  This is advantageous for conducting
image blur correction driving and still obtaining a high-
quality image.

[0063]  A set shutter speed of 1/30 second in a case where,
in Fig. 6, the mode is the shutter preferential AE mode
described in S705 and the subsequent steps in Fig. 4 will
now be described.

[0064]  The AE diagram for a case where the blur correction
driving unit 2 is not driven during image taking is
hereinafter referred to as "S".  In this diagram "S", the
shutter speed is fixed at 1/30 second within the range of f-
number of the aperture setting unit 10, and only outside
this range, the shutter speed is varied.  The f-number of
the maximum diameter is f2.8, and the minimum diameter has
F16.

[0065] The AE diagram for a case where the blur correction driving unit 2 is driven during image taking is hereinafter referred to as "Sco". Setting of an aperture does not change toward the open side even at a point where the aperture setting on the AE diagram reaches F3.2.

[0066] Description of the characteristic diagram regarding the above-mentioned aperture preferential AE mode is omitted here. When the blur correction driving unit 2 is not driven during image taking, an aperture of up to F2.8 on the open side can be set. When the blur correction driving unit 2 is driven during image taking, the range of possible apertures changes to cover F3.2 on the open side.

[0067] More specifically, when the image blur correction operating switch 15 is in a state "correction OFF", the set value of aperture is F2.8. With the aperture set value kept at his level, if the image blur correction operating switch 15 is turned to a state "correction ON", setting is automatically changed to F3.2.

[0068] Regarding aperture setting in the manual mode, the same applies. As described in Fig. 4, the manual mode includes a step of calculating the exposure error. When setting of f-number is automatically changed, therefore, a new amount of exposure error is calculated and displayed anew on the display unit 16.

[0069] The operating sequence upon setting an exposure and

during exposure in the image-blur-correctable camera of the present invention has been described above. It is not necessary for the Av limit value set at S6 in Fig. 3 above to keep a single value. Some cases of application regarding setting of this Av limit value will now be described.

[0070] Fig. 7 illustrates a case where setting of the Av limit value described above changes, depending upon the condition of the taking lens system 6. As described above, the image-blur-correctable lens system contains many difficulties in optical design. It is particularly difficult to maintain performance in short-distance image taking conducted while correcting the image blur or at the telephoto end or wide-angle end in a zoom lens.

[0071] As one of the solutions to alleviate design restrictions on a lens system under these conditions, it is effective to slightly reduce the open diameter of the lens system appropriately in response to the state of the lens system. Improving the depicting performance by these means is effective for reducing the design load and the manufacturing cost of the image-blur-correctable lens system.

[0072] For the purpose of appropriately reducing the aperture diameter of the lens system in response to the condition of the lens system, it is recommended to follow the Av limit value setting procedure in S6 described as to Fig. 3 in the steps shown in Fig. 7.

[0073]  To begin with, the position of the focus adjusting optical system in accordance with signals from the focal position detecting unit 4 in S601.

[0074]  Then, in S602, the position of the zoom optical system is detected in accordance with signals from the zoom position detecting unit 9 in S602.

[0075]  Then, in the next S603, an appropriate value is selected from among a plurality of numerical values of Av limit value stored in advance in the ROM unit of the CPU unit 1, and the thus selected value is set as an Av limit value which limits the operating range of the aperture driving unit 10.

[0076]  For example, when the state of a taking lens system 6 serving as a zoom lens is on the telephoto side, the Av limit value is set to "F3.5".  If it is on the wide-angle side, the Av limit value is set to "F3.2".

[0077]  Fig. 8 illustrates a concrete example of setting of the shutter speed and aperture value in the case of application described as to Fig. 7 mentioned above.  Fig. 8 represents a case where the exposure control mode of the camera is set in the program AE mode.

[0078]  This is substantially the same as the characteristic diagram described as to Fig. 5 above, serving as a program diagram for "PcoW" limiting the lens open diameter to F3.5 when the state of the taking lens system 6 which is a zoom

lens is on the telephoto side, and as a program diagram for "PcoT" limiting the lens open diameter to F3.2 when the state is on the wide-angle side.

[0079]  Although, in this example, the diagram takes the form of a single program diagram for the slashed portion of the program diagram, not in compliance with the state of the taking lens system 6, it is not limited to this method.  For example, it may be cased on a method in which the slashed portion of the program diagram varies with the focal distance of the taking lens system 6.

[0080]  Particularly along with the recent change in the focal distance, the f-number of the lens open diameter varies in many cases.  Even in these lens systems, application of the present invention poses no problem.  In short, it suffices to set a limitation on the possible open diameter for each focal distance in response to the presence of image blur correction driving.  A limit value may be set so as to achieve a smooth change in line with the change in the focal distance of the zoom lens, or it may be set stepwise for each of certain sections.

[0081]  As described above, furthermore, the program diagram or the Av limit value may be varied with the taking distance. The Av limit value may be altered on the basis of the result of multiplication of the focal distance and the image taking distance of the taking lens system 6.

[0082] Fig. 9 covers a case where the above-mentioned setting of an Av limit value varies with an image blur output detected by the blur detecting unit 3.

[0083] That is, when the extent of image blur is large upon image taking, the driving stroke of the blur correction driving unit 2 for correcting the image blur tends to become larger, and this may occur frequently up to near the drivable stroke limit. In this case, even luminous fluxes having passed through the extreme periphery of the lens system of the image blur correcting optical system (the fourth lens group 6d). It is not therefore easy to keep optical performance for obtaining a high-quality image.

[0084] For alleviating design restrictions of the taking lens system 6 under these conditions, it is effective to appropriately reduce the open distance of the lens system in response to the condition (focal position, zoom position and the like) of the taking lens system 6. In order to appropriately reduce the open diameter of the lens system, therefore, in accordance with the extent of image blur anticipated upon image taking, it is recommendable to follow the procedure of Av limit value setting in S6 described as to Fig. 3 in the manner shown in Fig. 9.

[0085] To begin with, the image blur detecting signal is entered from the blur detecting unit 3 in S611. Then, the output of image blur at a prescribed point in time is

determined from the state of input of the image blur
detection signal at the prescribed point in time in S612.
This determination of the extent of image blur may be made,
for example, by means of a peak value among image blur
signals within a prescribed period of time or from an amount
of integration of absolute values of image blur signals
within a prescribed period of time.

[0086]   Then, in S613, an appropriate value is selected from
among a plurality of Av limit values stored in advance in
the ROM unit of the CPU unit 1 in response to the extent of
image blur determined in the above-mentioned S612, and the
selected value is set as an Av limit value which limits the
operating range of the aperture driving unit 10.   For
example, when the extent of image blur is relatively large,
the Av limit value is set to "F3.5", and when the extent of
image blur is relatively small, it is suggested to set the
Av limit value to "F3.2".

[0087]   Fig. 10 illustrates a case where setting of an Av
limit value varies by the amount of shift driving of the
blur correction driving unit 2.   This case of application
suggests that, similarly to the case described with
reference to Fig. 9, when carrying out image blur correction
driving already in the preparatory state for image taking,
the extent of image blur may be determined on the basis of a
shift driving amount signal outputted by the blur correction

driving unit 2 as in this case of application.

[0088]  For example, when image blur is large and the amount of shift in the preparatory state for image taking frequently reaches the drivable stroke limit, it is considered to take place frequently that the amount of shift reaches near the drivable stroke limit.  When image blur is small and driving is limited to near the center, the prediction is just reverse to the above.

[0089]  First, in S621, a shift amount detection signal is entered from the blur correction driving unit 2.  Then, in S612, the extent of image blur at a prescribed point in time is determined from the state of input of the shift amount detection signal at a prescribed point in time.  This determination of the extent of image blur may be made, for example, by means of the peak value (maximum value of driving stroke) of the shift amount detection signal within a prescribed period of time, or from the amount of integration of absolute values of shift amount detection signals within the prescribed period of time.

[0090]  Then, in S613, an appropriate value is selected from among a plurality of Av limit values stored in advance in the ROM unit of the CPU unit 1 in response to the extent of image blur determined in the above-mentioned S612, and set the thus selected value as an Av limit value which limits the operating range of the aperture driving unit 10.  For

example, when the extent of image blur is relatively large, the Av limit value is set to "F3.5", and if the extent of image blur is relatively small, the Av limit value is preferably set to "F3.2".

[0091] Some cases of application have been described above with reference to Fig. 7 and the subsequent drawings, but the embodiments of the present invention are not limited to these cases. For example, when changing setting of the Av limit value in response to the state of the taking lens system 6 or the extent of image blur, an Av limit value may be selected in consideration of all these conditions.

[0092] In the embodiments described above, the Av limit value in a case including an image blur correcting operation has been set always as a value smaller than the lens open diameter (an aperture value having a larger f-number), but the present invention is not limited to this condition.

[0093] When a satisfactory result of image taking is available even if the blur correction driving is conducted with an open diameter of the taking lens system 6 because of a state of the taking lens system 6 (focal position, zoom position, etc) or an extent of image blur, an Av limit value of "F2.8" may be used to practically abolish the limitation.

[0094] In short, under conditions which permit easy improvement of optical performance in optical design as compared with conditions of other lens systems, and in

addition, when the extent of image blur is small, a case where the maximum open diameter of the lens system is allowed up to "F2.8" may occur as a result of application of the present invention.

[0095]  The image-blur-correctable camera of the present invention is not limited to the structure of the embodiment shown in Fig. 1, but the shape of various parts, structure and other particulars may be appropriately varied or modified, and various variations are of course conceivable.

[0096]

[Advantages]  According to the image-blur-correctable camera of the present invention, as described above, there is provided a camera comprising image blur detecting means which detects an amount of image blur; image blur correcting means which corrects an image blur in response to output of the image blur detecting means; aperture control means which controls aperture operation of a taking lens system; and aperture limiting means which limits the aperture controlling range of the taking lens system by the aperture control means during operation of the image blur correcting means.  It is therefore possible to obtain advantages of always achieving a satisfactory image taking performance through a good taking lens system even while performing image blur correction driving by cutting luminous fluxes around the taking lens system, thus always maintaining a

high image-taking quality.

[0097]  According to the present invention, furthermore, the aperture limiting means prevents the aperture of the taking lens system from becoming an open state, or limits the control range of the aperture control means in response to the state of the taking lens system, output of the image blur detecting means, the operating range of the image blur correcting means and the like.  Since it has a configuration in which it is inoperable when the image blur correcting means is in a non-operable state, it is possible to change the aperture limiting conditions of the taking lens system into required conditions in response to the state of the taking lens system or the extent of image blur, thus permitting display of the above-mentioned advantages more efficiently.

[0098]  Particularly, according to the present invention, the control range of the aperture control means can be limited by the aperture limiting means so as to prevent the aperture of the taking lens system from becoming in an open state even when the object brightness is low, during operation of the image blur correcting means.  It is therefore possible to permit display of the advantage of always maintaining a high image taking performance of the taking lens system and a high image quality.

[Brief description of the Drawings]

[Fig. 1]   Fig. 1 is a schematic configuration diagram illustrating an embodiment of the image-blur-correctable camera of the present invention;

[Fig. 2]   Fig. 2 is a block diagram for illustrating the image blur correcting control system in the image-blur-correctable camera shown in Fig. 1;

[Fig. 3]   Fig. 3 is a flowchart for illustrating the operating sequence of the image-blur-correctable camera of the present invention;

[Fig. 4]   Fig. 4 is a detailed flowchart for illustrating the operating sequence for fixing the shutter speed value and the aperture value in S7 in Fig. 3;

[Fig. 5]   Fig. 5 is a characteristic diagram for illustrating the shutter speed value and the aperture value in a case where the mode is the program AE mode;

[Fig. 6]   Fig. 6 is a characteristic diagram for illustrating the shutter speed value and the aperture value in a case where the mode is the shutter preferential AE mode;

[Fig. 7]   Fig. 7 is a flowchart for illustrating the operating sequence in a case of application where setting of the Av limit value in S6 in Fig. 3 is varied with the condition of the taking lens system;

[Fig. 8]   Fig. 8 is a characteristic diagram for illustrating the shutter speed value and the aperture value

in a case of application shown in Fig. 7;

[Fig. 9]   Fig. 9 is a flowchart for illustrating the operating sequence in a case of application where setting of the Av limit value in S6 in Fig. 3 is varied with output of image blur; and

[Fig. 10]   Fig. 10 is a flowchart for illustrating the operating sequence in a case of application where setting of the Av limit value I S6 in Fig. 3 is varied with the amount of shift driving.

[Reference Numerals]

1:          CPU unit

2:          Blur correction driving unit

3:          Blur detecting unit

4:          Focal position detecting unit

5:          Enclosure

6:          Taking lens system

7:          Focal cam ring

8:          Zoom cam ring

9:          Zoom position detecting unit

10:         Aperture driving unit

11:         Taking film

12:         Film sensitivity setting unit

13:         Shutter unit

14:         Release switch

15:         Image blur correction operating switch

16:     Display unit

17:     Photometer unit

18:     Exposure setting unit

FIG. 1

| | |
|---|---|
| 4: | FOCAL POSITION DETECTING UNIT |
| 9: | ZOOM POSITION DETECTING UNIT |
| 10: | APERTURE DRIVING UNIT |
| 2: | BLUR CORRECTION DRIVING UNIT |
| 3: | BLUR DETECTING UNIT |
| 1: | CPU UNIT |
| 13: | SHUTTER UNIT |


FIG. 2

SEMI-PRESSING OPERATION

FULL-PRESSING OPERATION

| | |
|---|---|
| 17: | PHOTOMETER UNIT |
| 18: | EXPOSURE SETTING UNIT |
| 14: | RELEASE SWITCH |
| 15: | IMAGE BLUR CORRECTION OPERATING SWITCH |
| 16: | DISPLAY UNIT |
| 4: | FOCAL POSITION DETECTING UNIT |
| 1: | CPU UNIT |
| 13: | SHUTTER UNIT |
| 9: | ZOOM POSITION DETECTING UNIT |
| 10: | APERTURE DRIVING UNIT |
| 2: | BLUR CORRECTION DRIVING UNIT |
| | MONITOR UNIT |
| 3: | BLUR DETECTING UNIT |

12:        FILM SENSITIVITY SETTING UNIT


FIG. 3

S1:        START

S2:        INPUT Sv

S3:        INPUT Bv

S4:        CALCULATE Ev

S5:        IMAGE BLUR CORRECTION ON?

S6:        SET Av LIMIT VALUE

S7:        FIX Av, Tv

S8:        DISPLAY

S9:        FULL-PRESSING SW ON?

S10:       EXPOSURE OPERATION

S11:       END


FIG. 4

(S6 OR S5)

S701:        PROGRAM AE MODE?

S702:        SHUTTER PREFERENTIAL AE MODE?

S703:        APERTURE PREFERENTIAL AE MODE?

S707:        INPUT Av SETTING VALUE

S709:        INPUT Tv SETTING VALUE

S705:        INPUT Tv SETTING VALUE

S704:        FIX Av, Tv

S708:        FIX Av, Tv

S710:         INPUT Av SETTING VALUE

S706:         FIX Av, Tv

S711:         FIX Av, Tv

S712:         CALCULATE EXPOSURE ERROR


FIG. 5

LENS APERTURE

SHUTTER SPEED


FIG. 6

LENS APERTURE

SHUTTER SPEED


FIG. 7

S601:    INPUT FOCAL POSITION INFORMATION

S602:    INPUT ZOOM POSITION INFORMATION

S603:    SET Av LIMIT VALUE


FIG. 8

LENS APERTURE

SHUTTER SPEED


FIG. 9

S611:    INPUT IMAGE BLUR INFORMATION

S612:    DETERMINE IMAGE BLUR EXTENT

S613:     SET Av LIMIT VALUE


FIG. 10

S621:     INPUT BLUR CORRECTING OPTICAL SYSTEM SHIFT AMOUNT

S622:     DETERMINE IMAGE BLUR EXTENT

S623:     SET Av LIMIT VALUE